

Gas-to Liquids (GTL) Production

Overview

The United States is reliant on imported crude oil and growing imports of petroleum products to meet growing demand for clean transportation fuels. With rising prices, and concern over reliance on these imports and the impact on our nation's energy security, there is growing interest in producing transportation fuels from alternative energy sources, such as stranded natural gas, coal, petroleum coke, oil shale, tar sands, and biomass.

Gas-to-liquids (GTL) technology converts natural gas to clean liquid fuels in a process that initially converts natural gas to synthesis gas (a mixture of hydrogen and carbon monoxide) followed by a conversion process to liquid fuels. The conversion to synthesis gas is the process used to produce hydrogen from fossil fuels. Although GTL technology at commercial scale exists today, it is uneconomic using market priced natural gas in conventional steam methane reforming (SMR) or auto-thermal reforming (ATR) to produce synthesis gas, followed by the conversion process, such as the Fischer-Tropsch (F-T) process. The GTL process produces synthetic transportation fuels that are zero-sulfur, fully fungible products compatible with existing liquid fuels and which can be introduced into the current infrastructure and supply system. GTL is capital intensive with capital cost ranging from \$25,000 to \$45,000 per daily barrel. To be economic, RD&D is needed to lower the cost and improve the efficiency of this system, and requires extremely low-value stranded natural gas.

Stranded natural gas is in remote locations and/or cannot be economically produced because of inadequate transportation infrastructure. A large source of natural gas is in Alaska. The proposed Alaska natural gas pipeline, with a capacity of 1.5 TCF per year, would bring 35 TCF of known Alaskan North Slope natural gas to U.S. markets, with ultimate gas recovery predicted at over 100 TCF. Over 30 years, the pipeline would transport less than half of the predicted recoverable gas resources, leaving an opportunity to convert remaining natural gas resources to GTL, which could be transported through the Trans Alaska Pipeline System (TAPS). Other stranded natural gas (e.g., from offshore production) could also be converted to GTL with improved technology.

Background

In the past, under the Ultra-Clean Transportation Fuel Program, the Office of Oil & Natural Gas (ONG) in the Office of Fossil Energy has funded joint industry-DOE RD&D projects on production and testing of GTL. Currently, the Ion Transport Membrane (ITM) Synthesis Gas (Syngas) project is a promising government/industry cost-shared technology. This novel technology has the potential to reduce the capital cost to produce synthesis gas by over 25% compared to oxygen-fed ATR. There are also advantages to ITM Syngas compared to SMR technology when carbon capture is desired.

The ITM Syngas process combines the separate processes for air separation and high temperature syngas generation into a single process where oxygen is separated and reacted with natural gas to produce syngas in a single unit operation. This combination of processes generates the potential for significant reductions in capital cost and in space requirement.

Because of its small size and weight, ITM Syngas technology is particularly suitable for modest-size gas field exploitation and associated gas opportunities, including offshore applications. This opens up the viability of GTL for much smaller fields and stranded gas resources.

Research, Development and Demonstration Status and Challenges

The ITM Syngas technology is not yet ready for commercialization. ITM membranes are fabricated from non-porous, multi-component metallic oxides that operate at high temperatures and have exceptionally high oxygen flux and selectivity.

To date, the program has successfully developed and run a Process Development Unit (about 0.7 barrels per day), which successfully demonstrated the use of new methods that were developed to improve the operation of the ITM Syngas membranes during start-up.

Major challenges are seen as assembly of full-height modules; reliability of full-size membranes during operating transients; and design of the next-level Subscale Engineering Prototype (15 barrels per day) for testing. Further testing will be required in larger pre-commercial units, assuming success in these smaller prototypes.

GTL Production in the Annual Energy Outlook

Conventional GTL technology is included in the 2006 Annual Energy Outlook (AEO2006), which states capital costs for GTL plants range from \$25,000 to \$45,000 (2004 dollars) per barrel of daily capacity, depending on production scale and site selection. Those costs have dropped from the \$100,000 costs for the earliest plants. AEO2006 also states that GTL is profitable when crude oil prices exceed \$25 per barrel and natural gas prices are in the range of \$0.50 to \$1.00 per million Btu, with the economics extremely sensitive to natural gas feedstock costs. AEO2006 projects domestic GTL production originating in Alaska, and in the high oil price case will reach 200,000 barrels per day in 2030.

GTL Production Assuming Successful RD&D

Assuming successful RD&D of the ITM Syngas Reactor project, the synthesis gas production capital cost will be reduced by over 25% compared to conventional technology. The lower capital cost will improve the economic incentive to produce GTL from remote and/or stranded locations.

Assumptions

The Alaska natural gas proved reserves are about 35 TCF. Development of GTL from the newly discovered stranded natural gas reserves in Alaska will occur and will utilize the TAPS to deliver GTL, commingled with Alaska North Slope crude oil, to the U.S. markets.

The production of 1 barrel of GTL is assumed to require 8,000 cubic feet of natural gas. In the Low Case, no GTL of any significant quantity is produced in the United States.

In the Medium Case, technology is successful and reduces the synthesis gas capital cost by 25% over ATR technology. One plant is built in 2020 at 50,000 barrels per day, and a second 50,000 barrels per day plant is streamed by 2025. One additional plant is built by 2030 for a total of 150,000 barrels per day by 2030 from Alaskan natural gas.

In the High Case, technology is successful and reduces the synthesis gas capital cost by 25% over ATR technology. The higher price in this case provides additional incentive to exploit the underutilized TAPS and increase production of GTL. In the high case, one plant at 50,000 barrels per day is built by 2020, two more are built by 2025, and a total of 4 – 50,000 barrel per day plants will have been built by 2030, for a total production of 200,000 barrels per day of GTL. This amount of GTL requires nearly 0.6 TCF per year of natural gas, with a total of about 18 TCF of gas for 30 years, which is approximately half the total current proved Alaska natural gas reserves.

Table 1. GTL Production with Conventional Technology

GTL	Low Case (a)	Medium Case	High Case
Assumptions	No new government policies; conventional GTL technology; AEO2006 Reference Case Prices	No new government policies; successfully reaches GTL technology goals; AEO2006 Reference Case Prices	No new government policies; successfully reaches GTL technology goals; AEO2006 High Oil Prices
Production			
2020	0	50,000 barrels per day	50,000 barrels per day
2025	0	100,000 barrels per day	150,000 barrels per day
2030	0	150,000 barrels per day	200,000 barrels per day